GEOLOGIC AND WELL-CONSTRUCTION DATA FOR THE H-10 BOREHOLE COMPLEX NEAR THE PROPOSED WASTE ISOLATION PILOT PLANT SITE, SOUTHEASTERN NEW MEXICO

By J. G. Wells (U.S. Geological Survey)

and S.L. Drellack, Jr. (Fenix and Scisson, Inc.)

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 83-4124

Prepared in cooperation with the

U.S. DEPARTMENT OF ENERGY

Albuquerque, New Mexico

1983

UNITED STATES DEPARTMENT OF THE INTERIOR

JAMES G. WATT, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
Water Resources Division
505 Marquette, NW, Room 720
Albuquerque, New Mexico 87102

For sale by:

Open-File Services Section
Branch of Distribution
U.S. Geological Survey, MS 306
Box 25425, Denver Federal Center
Denver, Colorado 80225
(303) 234-5888

CONTENTS

ILLUSTRATIONS

PLATE

TABLES

CONVERSION FACTORS

All measurements related to the drill site are given in inch-pound units. These measurements include: The survey to locate the borehole (both horizontally and vertically), the drilling depths as provided by the driller, and the wire-line log recordings as provided by the logging company. Unless otherwise noted, altitude and depth measurements are referenced to ground level. The following table contains factors for converting to International System of Units (SI).

Multiply inch-pound units	By	To obtain SI units
foot	0.3048	meter
inch	25.4	millimeter
pound	0.4536	kilogram
pound per square inch	0.006895	megapascal
mile	1.609	kilometer

National Geodetic Vertical Datum of 1929 (NGVD of 1929): a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level." NGVD of 1929 is referred to as sea level in this report.

The use of trade names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

GEOLOGIC AND WELL-CONSTRUCTION DATA FOR THE H-10 BOREHOLE COMPLEX NEAR THE PROPOSED WASTE ISOLATION PILOT PLANT SITE, SOUTHEASTERN NEW MEXICO

By J. G. Wells (U.S. Geological Survey)

and S. L. Drellack, Jr. (Fenix and Scisson)

ABSTRACT

The H-10 borehole complex, a group of three closely spaced boreholes, is located 4 miles southeast of the proposed Waste Isolation Pilot Plant site in west-central Lea County, New Mexico. The holes were drilled during August and October 1979 to obtain geologic and hydrologic data to better define the regional ground-water-flow system. The geologic data presented in this report are part of a site-characterization study for the possible storage of defense-associated radioactive wastes within salt beds of the Salado Formation of Permian age. The geologic data include detailed descriptions of cores, cuttings, and geophysical logs.

Each borehole was designed to penetrate a distinct water-bearing zone: H-10a (total depth 1,318 feet) was completed just below the Magenta Dolomite Member of the Rustler Formation of Permian age; H-10b (total depth 1,398 feet) was completed just below the Culebra Dolomite Member of the Rustler Formation; and H-10c (total depth 1,538 feet) was completed below the Rustler Formation-Salado Formation contact. The geologic units penetrated in borehole H-10c are surficial alluvium and eolian sand of Holocene age (0-5 feet); the Mescalero caliche (5-9 feet) and the Gatuna Formation (9-90 feet) of Pleistocene age; formations in the Dockum Group (Chinle (?) Formation, 90-482 feet and Santa Rosa Sandstone, 482-658 feet) of Late Triassic age; and the Dewey Lake Red Beds (658-1,204 feet), the Rustler Formation (1,204-1,501 feet), and part of the Salado Formation (1,501-1,538 feet), all of Permian age. The sections of the Rustler and Salado Formations penetrated by borehole H-10c are complete and contain little or no evidence of dissolution of halite and associated rocks, indicating that the eastward-moving dissolution within the Rustler or on top of the Salado, found west of the Waste Isolation Pilot Plant site, has not reached the H-10 site.

INTRODUCTION

The H-10 borehole complex (SW¼SE¼ sec. 20, T. 23 S., R. 32 E.) was drilled in west-central Lea County, New Mexico (fig. 1), at the request of the Waste Isolation Pilot Plant (WIPP) project office of the U.S. Department of Energy. Sandia National Laboratories is evaluating the WIPP site for the Department of Energy as a potential repository for the disposal of defense-associated transuranic wastes in Permian salt beds. The U.S. Geological Survey is participating in this evaluation by developing information on the ground-water hydrology of the region, obtaining geologic borehole data, and conducting hydrologic tests in boreholes on and near the WIPP site. This report provides well-construction information as well as lithologic data about the Rustler and Salado Formations and the top of the salt interval within the Salado Formation at the H-10 borehole complex. The geologic information will provide a basis for determining the occurrence and movement of ground water in certain water-bearing zones above and below the salt. An understanding of the regional geology and hydrology is necessary for predicting the capability of the water-bearing zones to transport radionuclides to the biosphere in the event the storage facility is breached. Previous studies (Mercer and Orr, 1979; and Powers and others, 1978) indicate water-bearing zones within and at the lower contact of the Rustler Formation of Permian age probably require the most detailed study.

The H-10 borehole complex is one in a series of four complexes that has been drilled near the WIPP site for determining regional geologic and hydrologic characteristics. At each complex a cluster of three boreholes (fig. 2) was completed in successively deeper water-bearing zones. The borehole designated "a" penetrated the Magenta Dolomite Member of the Rustler Formation, the "b" borehole penetrated the Culebra Dolomite Member of the Rustler Formation, and the "c" borehole penetrated the Rustler Formation-Salado Formation contact.

Data for the geologic section at the H-10 borehole complex are tabulated in plate 1 and table 1. Most of each borehole was drilled by the air-rotary method. Drill cuttings collected at 5-foot intervals and cores from selected intervals were used to describe the rocks penetrated in each borehole (tables 2-7). Wire-line geophysical logs (plate 1) were made in the H-10c borehole to (1) aid in the recognition and correlation of rock units; (2) assist in identification of major lithologies; and (3) provide information about rock porosities for hydrologic evaluation.

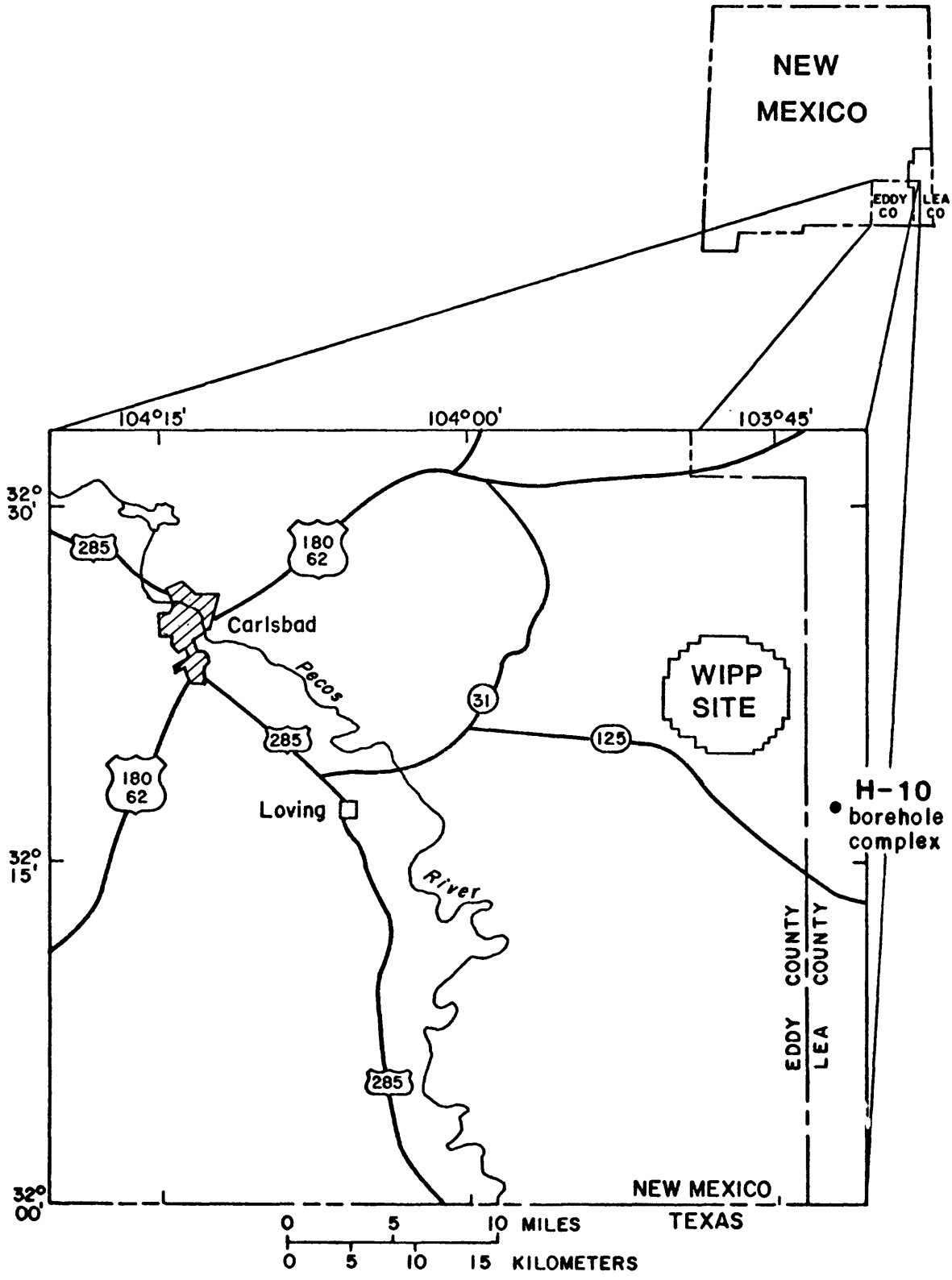

Figure 1.--Location of H-10 borehole complex with respect to the Waste Isolation Pilot Plant site.

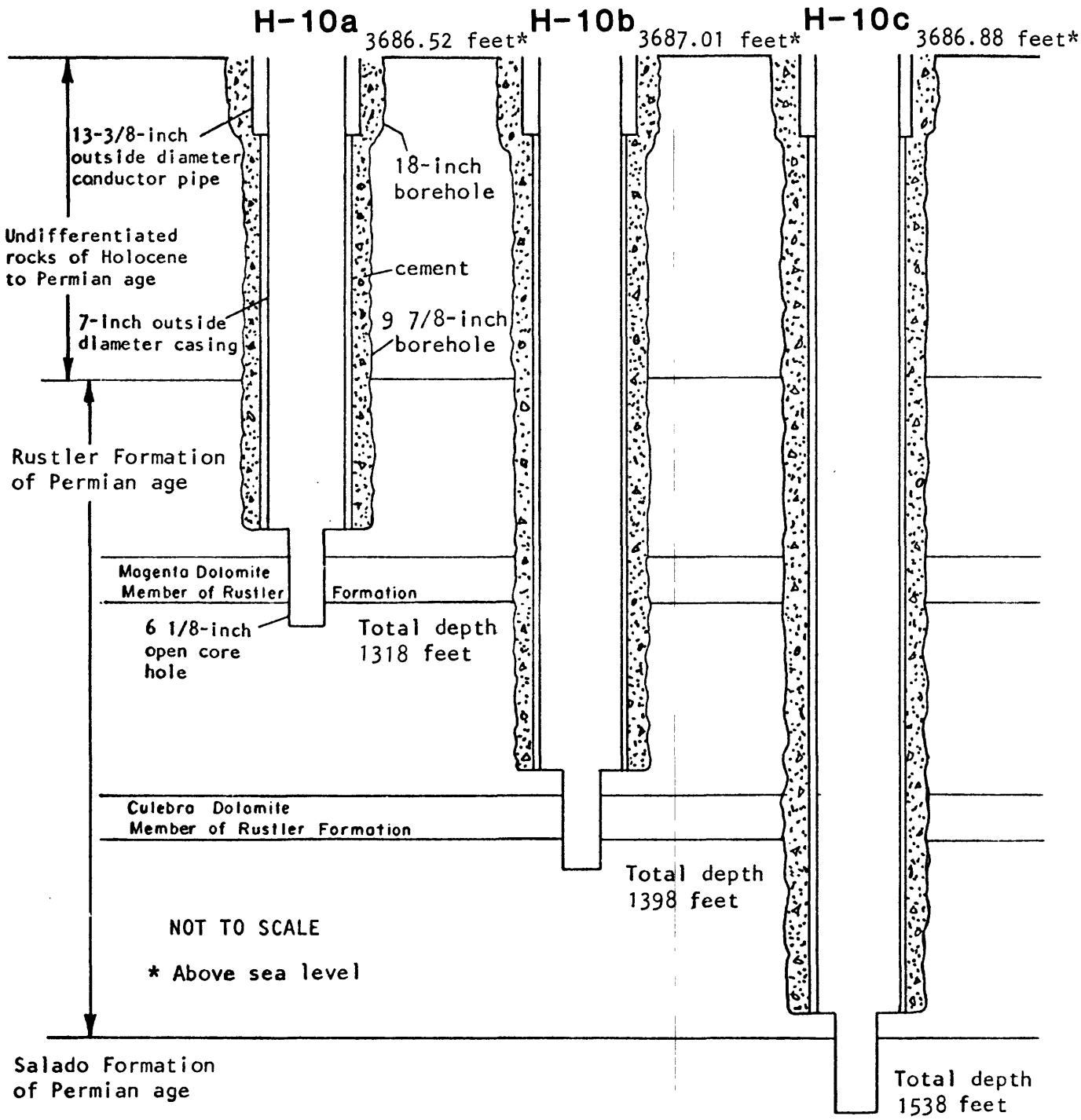

Figure 2.--Schematic diagram of the H-10 borehole complex.

BOREHOLE DRILLING AND SAMPLING METHODS

The H-10 borehole complex 4 miles southeast of the proposed WIPP site, drilled during August and October 1979, consists of three boreholes (H-10a, H-10b, and H-10c) located 100 feet apart in an equilateral triangle. Borehole H-10c was drilled first and penetrated the Rustler Formation-Salado Formation contact 37 feet above the total depth of 1,538 feet measured from a land-surface altitude of 3,686.88 feet above sea level. Borehole H-10b was drilled next to a total depth of 1,398 feet and penetrated the Culebra Dolomite Member. Borehole H-10a was drilled last to a total depth of 1,318 feet and penetrated the Magenta Dolomite Member (fig. 2).

Rotary drilling procedures with mud and air-mist were used to drill borehole H-10c. A standard rock bit was used for drilling when cuttings were being collected at 5-foot intervals in selected zones of borehole H-10c from ground level to a depth of 1,483 feet. Wire-line coring procedures were used at the other selected intervals to cut continuous cores at 1,230-1,281 feet (which included the Magenta at 1,256-1,280 feet), 1,346-1,394 feet (which included the Culebra at 1,360-1,387 feet), and 1,489-1,518 feet (which included the Rustler-Salado contact at 1,501 feet and the top of the salt also at 1,501 feet). The cuttings and core were examined and described at the drillsite and then transported to the Sandia National Laboratories warehouse in Carlsbad, New Mexico, for storage.

Prior to setting casing, a suite of wire-line geophysical logs was made from land surface to depths ranging from 1,478 to 1,486 feet of borehole H-10c under open-hole, fluid-filled conditions. The logging was done to facilitate the identification and correlation of rock units and to provide a depth determination independent of that indicated by drill-pipe measurements. The geophysical logs include: (1) a gamma-ray curve, which recorded variations in the content of potassium and other radioactive elements; (2) a gamma-gamma curve, which recorded variations in rock density; and (3) a neutron curve, which recorded porosity.

The casing was set in borehole H-10c at 1,483 feet below land surface and the annular space between formation and casing was filled with cement. Afterwards, 29 feet of the borehole were cored from 1,489 to 1,518 feet and an additional 20 feet of borehole (for storing logging tools or preparing for a drill stem test) were drilled to a total depth of 1,538 feet below land surface.

Borehole H-10a was air-rotary drilled to just above the Magenta Dolomite Member; H-10b was rotary drilled with mud to 639 feet, was cored from 639 to 659 feet using wire-line coring procedures, and was rotary drilled again with mud to just above the Culebra Dolomite Member. Forty feet of borehole H-10a and 50 feet of borehole H-10b were cored after the casing was set and cemented to the surface, as in borehole H-10c. The holes were geophysically logged after the total depth of each hole was reached.

GEOLOGIC DATA

Borehole H-10c with a total depth of 1,538 feet, is the deepest borehole at the H-10 complex. For this reason, the geologic section penetrated by H-10c is summarized in table 1.

The geologic section includes continental sediments of Quaternary and Triassic age and marine red beds and evaporites of Permian age. The Quaternary sediments include, in order of increasing age, unconsolidated alluvium and eolian sand of Holocene age, and the Mescalero caliche and Gatuna Formation of Pleistocene age. Sediments of Late Triassic age include two formations in the Dockum Group: an upper shaly unit (Chinle (?) Formation) and the lower Santa Rosa Sandstone. The Permian rocks include, in order of increasing age, the Dewey Lake Red Beds, the Rustler Formation, and the upper 37 feet of the Salado Formation. The Permian rocks are present in the lower 880 feet of the geologic section penetrated by borehole H-10c.

The unconsolidated alluvium and eolian sand are an informal unit that is 5-feet thick. The Mescalero caliche, another informal stratigraphic unit, is a well-lithified calcareous soil that underlies the eolian sand from 5 to 9 feet below land surface. The Gatuna Formation underlies the Mescalero caliche and is 81-feet thick as interpreted from geophysical logs (plate 1). Samples were available for only 5.8 feet of the total Gatuna Formation thickness; therefore, a general description of the formation in southeastern New Mexico follows: light-reddish-brown, friable, fine- to medium-grained, sub-angular to sub-round, well-sorted sandstone with zones of coarse conglomerate (Bachman, 1974).

The upper unit of the Dockum Group (Chinle (?) Formation, 90-482 feet) underlies the Gatuna Formation and consists of reddish-brown to brownish-gray sandstone and reddish-brown, greenish-gray, and brownish-gray mudstone and siltstone. The lower unit of the Dockum Group is the Santa Rosa Sandstone (482-658 feet), a grayish-red, fine- to medium-grained, poorly sorted sandstone with interbeds of reddish-brown siltstone and mudstone.

Borehole H-10c penetrated the Dewey Lake Red Beds at 658 feet below land surface. The Dewey Lake Red Beds are reddish-brown, poorly to moderately consolidated sandstone and siltstone with greenish-gray spots. Veins of fibrous selenite, commonly present in the formation, are present at depths below 768 feet.

The Rustler Formation, from 1,204 to 1,501 feet below land surface, consists chiefly of gypsum, remnant anhydrite, and minor amounts of moderately to poorly consolidated clay and silt (derived from argillaceous and silty halite). The Rustler Formation also contains the Magenta and Culebra Dolomite Members, and a lower member of well consolidated siltstone containing some halite. At the H-10 borehole complex the Magenta is a light olive-gray, very finely crystalline, silty dolomite with selenite veins and

argillaceous laminae; the Culebra is a pitted, light-olive-gray to yellowish-gray, very finely crystalline dolomite with gypsum-healed fractures.

The last 37 feet of section, between 1,501 and 1,538 feet below land surface, is part of the Salado Formation and consists of halite and argillaceous halite with traces of polyhalite. Little or no dissolution of halite and associated rocks has occurred at the top of the Salado Formation indicating that the eastward-moving dissolution within the Rustler Formation and on top of the Salado, found west of the WIPP site, has not reached the H-10 site (Mercer and Orr, 1979).

The lithologies penetrated by borehole H-10c are interpreted and correlated with selected geophysical logs in plate 1. Drilling and well-completion details of the H-10 boreholes are given in tables 2 through 4. Core descriptions from boreholes H-10a and H-10b are presented in tables 5 and 6, respectively, and the core and cuttings from borehole H-10c are described in table 7.

SUMMARY

The H-10 borehole complex, a group of three closely spaced boreholes, was drilled southeast of the WIPP site in west-central Lea County, New Mexico, during August and October 1979. The boreholes were drilled to obtain geologic data and to conduct hydrologic tests to better define the regional ground-water-flow system. The H-10 complex was drilled as part of a site-characterization study for the possible storage of defense-associated wastes within salt beds of the Salado Formation of Permian age. Cores and cuttings from the borehole complex and geophysical logs from borehole H-10c were described or interpreted for this study.

Each borehole was completed just below a distinct water-bearing zone. Borehole H-10a (total depth 1,318 feet) penetrated the Magenta Dolomite Member, a light-olive-gray silty dolomite of the Rustler Formation. Borehole H-10b (total depth 1,398 feet) penetrated the Culebra Dolomite Member, a light-olive-gray to yellowish-gray, fractured and pitted dolomite of the Rustler Formation. Rocks penetrated by borehole H-10c (total depth 1,538 feet) at the Rustler Formation-Salado Formation contact consist of dark-reddish-brown to greenish-gray siltstone at the base of the Rustler Formation, which grade to olive-gray clayey anhydrite followed by the argillaceous halite, halite, and polyhalite interval of the Salado Formation. Within the Rustler Formation and at the top of the Salado Formation, little or no dissolution residue is present, indicating that the eastward-moving dissolution found west of the WIPP site, has not reached the H-10 site.

SELECTED REFERENCES

Bachman, G. O., 1974, Geologic processes and Cenozoic history related to salt dissolution in southeastern New Mexico: U.S. Geological Survey Open-File Report 74-194, 81 p.

_____1976, Cenozoic deposits of southeastern New Mexico and an outline of the history of evaporite dissolution: U.S. Geological Survey Journal of Research, v. 4, no. 2, p. 135-149.

Bachman, G. O., and Johnson, R., 1973, Stability of salt in the Permian Salt Basin of Kansas, Oklahoma, Texas, and New Mexico: U.S. Geological Survey open-file report, 62 p.

Goddard, E. N., and others, 1948, Rock-color chart: Washington, National Research Council (reprinted by Geologic Society of America, 1975).

Jones, C. L., 1973, Salt deposits of Los Medaños area, Eddy and Lea Counties, New Mexico, with sections on Ground-water hydrology by M.E. Cooley, and Surficial geology by G. O. Bachman: U.S. Geological Survey open-file report, 67 p.

Mercer, J. W., Davis, P. A., Dennehy, K. F., and Goetz, C. L., 1981, Results of hydrologic tests and water-chemistry analyses, wells H-4a, H-4b, H-4c, at the proposed Waste Isolation Pilot Plant site, southeastern New Mexico: U.S. Geological Survey Water-Resources Investigations 81-36, 92 p.

Mercer, J. W., and Orr, B. R., 1979, Interim data report on the geohydrology of the proposed Waste Isolation Pilot Plant site, southeast New Mexico: U.S. Geological Survey Water-Resources Investigations 79-98, 178 p.

Powers, D. W., Lambert, S. J., Shaffer, S. E., Hill, L. R., and Weart, W. D., editors, 1978, Geological characterization report, Waste Isolation Pilot Plant (WIPP) site, southeastern New Mexico--v. I and II: Albuquerque, New Mexico, Sandia National Laboratories, SAND 78-1596.

Sandia National Laboratories and U.S. Geological Survey, compilers, 1980a, Basic data report for drillhole WIPP 19: Albuquerque, New Mexico, Sandia National Laboratories, SAND 79-0276, 27 p., 4 appendices.

_____1980b, Basic data report for drillhole WIPP 21: Albuquerque, New Mexico, Sandia National Laboratories, SAND 79-0277, 18 p., 4 appendices.

Vine, J. D., 1963, Surface geology of the Nash Draw quadrangle, Eddy County, New Mexico: U.S. Geological Survey Bulletin 1141-B, 46 p.

Table 1.—Summary of geologic units penetrated by borehole H-10c

Rock unit	Depth interval [1] (feet)
Holocene deposits [2]	
Unconsolidated alluvium and eolian sand	0-5
Pleistocene rocks	
Mescalero caliche	5-9
Gatuna Formation	9-90
Triassic rocks	
Dockum Group	
Chinle (?) Formation	90-482
Santa Rosa Sandstone	482-658
Permian rocks	
Dewey Lake Red Beds	658-1,204
Rustler Formation	1,204-1,501
Magenta Dolomite Member	1,256-1,280
Culebra Dolomite Member	1,360-1,387
Salado Formation	1,501
Top of salt interval	1,501
Total Depth of Borehole	1,538

[1] Depth interval recorded from gamma-ray and bulk-density logs (corrected to land surface) made by Dresser Atlas on August 16, 1979.

[2] Includes artificial fill for drill pad.

Table 2.—Drilling and well-completion record of borehole H-10a

Location: Sec. 20, T. 23 S., R. 32 E.
433.04 feet from the south line
2,068.91 feet from the east line

Altitude (land surface) above sea level: 3,686.52 feet. Datum for depth measurements in drilling and logging operations.

Lithologic log prepared by: S. L. Drellack, Jr., J. L. Gonzales, A. F. McIntyre, (Fenix and Scisson, Inc.) and K. F. Dennehy (U.S. Geological Survey)

Drilling Contractor: Verna Drilling Company.

Drilling Record:

Commenced drilling on August 21, 1979, and completed on August 26, 1979, at 1318 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and cemented in place. Drilled with a rock bit to 1,243 feet below land surface, hole was widened from 7 7/8 to 9 7/8 inches and 1,243 feet of 7-inch outside diameter casing was set and cemented in place.

41.3 feet of 3 1/2-inch O.D. core were recovered from 1,247 to a depth of 1,287 feet, 1.3 feet of excess core recovered (completed hole diameter was 6 1/8 inches). Hole was drilled with a rock bit to a total depth of 1,318 feet.

The hole was blown dry and made ready for hydrologic studies.

Core no.	Depth interval (feet) From	To	Revolutions per minute	Weight on bit (pounds)	Circulation medium	Feet cored	Feet recovered	Percent recovery
1	1,247	1,257	80	10,000	Airmist	10.0	9.8	98
2	1,257	1,267	80	10,000	Airmist	10.0	10.4	104
3	1,267	1,277	80	10,000	Airmist	10.0	9.3	93
4	1,277	1,287	80	10,000	Airmist	10.0	11.8	118

Table 3.—Drilling and well-completion record of borehole H-10b

Location: Sec. 20, T. 23 S., R. 32 E.
484.54 feet from south line
1,981.84 feet from east line

Altitude (land surface) above sea level: 3,687.01 feet. Datum for depth measurements in drilling and logging operations.

Lithologic log prepared by: S. L. Drellack, Jr., J. L. Gonzales, A. F. McIntyre (Fenix and Scisson, Inc.), and K. F. Dennehy (U.S. Geological Survey).

Drilling Contractor: Verna Drilling Company

Drilling Record:

Commenced drilling on Octover 7, 1979, and completed on October 13, 1979, at 1,398 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and cemented in place. Drilled with a rock bit to 1,346 feet below land surface (with one interim coring point at 639 to 659 feet), hole was widened from 7 7/8 to 9 7/8 inches and 1,346 feet of 7-inch outside-diameter casing was set and cemented to surface.

48.9 feet of 3 1/2-inch outside-diameter core were recovered from 1,348 to a total depth of 1,398 feet, 1.1 feet of core not recovered (completed hole diameter was 6 1/8 inches).

Hole was blown dry and made ready for hydrologic studies.

Core no.	Depth interval (feet) From	To	Revolutions per minute	Weight on bit (pounds)	Circulation pressure (pound per square inch)	Feet cored	Feet recovered	Percent recovery
1	639	649	80	12,000	1,000	10.0	9.4	94
2	649	659	80	12,000	1,000	10.0	10.2	102
3	1,348	1,358	80	10,000	250	10.0	9.6	96
4	1,358	1,368	80	10,000	250	10.0	9.6	96
5	1,368	1,378	80	10,000	250	10.0	9.9	99
6	1,378	1,388	80	10,000	250	10.0	9.4	94
7	1,388	1,398	80	10,000	250	10.0	10.4	104

Table 4.—Drilling and well-completion record of borehole H-10c

Location: Sec. 20, T. 23 S., R. 32 E.
384.54 feet from south line
1,981.84 feet from east line

Altitude (land surface) above sea level: 3,686.88 feet. Datum for depth measurements in drilling and logging operations.

Lithologic log prepared by: S. L. Drellack, Jr., J. L. Gonzales, A. F. McIntyre (Fenix and Scisson, Inc.), and K. F. Dennehy (U.S. Geological Survey).

Drilling Contractor: Verna Drilling Company

Drilling Record:

Commenced drilling on August 11, 1979, and completed on August 20, 1979, at 1,538 feet below land surface.

Conductor pipe (13 3/8 inches outside diameter) set at 38 feet below land surface and cemented in place.

Drilled with a rock bit to 1,483 feet (with two interim coring points at 1,230-1,281 and 1,346-1,394 feet), geophysical wireline logs were made by Dresser Atlas.

Hole was widened from 7 7/8 to 9 7/8 inches at 710 to 1,483 feet and 1,483 feet of 7-inch outside diameter casing was set and cemented in place.

27.6 feet of 3-1/2 inch outside-diameter core were recovered from 1,489 feet to a depth of 1,518 feet, 1.4 feet of core not recovered. Drilled with a rock bit from 1,518 to a total depth of 1,538 feet, (completed hole diameter was 6 1/8 inches).

Hole was blown dry and made ready for hydrologic studies.

Core no.	Depth interval (feet) From	To	Revolutions per minute	Weight on bit (pounds)	Circulation pressure (pounds per square inch)	Feet cored	Feet recovered	Percent recovery
1	1,230	1,240	70	10,000- 7,000	300	10.0	8.5	85
2	1,240	1,250	70	6,000	300	10.0	7.2	72
3	1,250	1,261	90	10,000-12,000	200	11.0	11.0	100
4	1,261	1,271	72	12,000-14,000	150	10.0	10.0	100
5	1,271	1,281	70	6,000	300	10.0	8.9	89
6	1,346	1,356	70	14,000	200	10.0	10.0	100
7	1,356	1,367	80	10,000	200	11.0	10.0	91
8	1,367	1,374	80	10,000	200	7.0	8.1	116
9	1,374	1,384	80	10,000	200	10.0	9.7	97
10	1,384	1,394	80	10,000	200	10.0	10.6	106
11	1,489	1,498	95	10,000	250	9.0	8.2	91
12	1,498	1,508	95	10,000	250	10.0	9.0	90
13	1,508	1,518	95	10,000	250	10.0	10.4	104

Table 5.—Lithology penetrated by borehole H-10a

Lithologic description	Depth interval (feet)
Anhydrite, light-olive-gray (5Y 6/1), very finely crystalline, mottled by irregular veins and veinlets of wavy, horizontal, discontinuous and continuous, 1- to 30-millimeter thick olive-black (5Y 4/1) to light-olive-gray (5Y 6/1) gypsum ----------	1,246.8-1,249.4
Gypsiferous anhydrite, olive-black (5Y 2/1) to light-olive-gray (5Y 6/1), very finely crystalline, slightly mottled by veinlets and veins of very finely crystalline, horizontal, light-olive-gray (5Y 6/1), dolomitic gypsum from 1,250.5 to 1,250.7 feet; few irregular, mostly horizontal selenite veins from 1,250.4 to 1,250.9 feet ---	1,249.4-1,250.9
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline; wavy, continuous, 8- to 10-millimeter thick, fibrous, translucent to transparent, selenite vein at 1,250.9 feet; horizontal, fibrous, translucent to transparent, selenite veins at 1,251.3 feet, 5- to 6-millimeters thick at 1,251.5 feet, 3-millimeters thick at 1,251.5 to 1,251.6 feet, 10-millimeters thick vein offset 16 millimeters; selenite-filled fracture dipping 68°; numerous minute blebs of white (N9) to medium-light-gray (N6) gypsum at 1,252.3 to 1,252.5 feet --------	1,250.9-1,252.5
Anhydrite, light-olive-gray (5Y 6/1), very finely crystalline, slightly gypsiferous; becoming dolomitic at 1,253.6 to 1,254.0 feet ----------	1,252.5-1,254.0
Dolomite, light-olive-gray (5Y 6/1), poorly consolidated, very coarsely crystalline; horizontal, transparent to translucent selenite band at 1,254.1 to 1,254.2 feet -----	1,254.0-1,255.3
Dolomite, light-olive-gray (5Y 6/1), some small-scale crossbedding with very thin (less than 1-millimeter thick) wavy, olive-gray (5Y 4/1) laminae ----------	1,255.3-1,256.8

Table 5.—Lithology penetrated by borehole H-10a - Concluded

Lithologic description	Depth interval (feet)
No core	1,256.8-1,257.0
Dolomite, same as in unit from 1,255.3 to 1,256.8 feet; few 1- to 4-millimeters thick, fibrous, translucent to transparent selenite veins at 1,266.9 to 1,267.0 feet --	1,257.0-1,267.0
Dolomite, light-olive-gray (5Y 6/1), some small-scale cross-bedding with very thin (less than 1-millimeter thick) wavy, olive-gray (5Y 4/1) laminae; numerous veins of horizontal, wavy, sometimes irregular, fibrous, translucent to transparent, selenite, forming interconnecting network, 1- to 5-millimeters thick, more predominant at 1,268.8 to 1,274.3 feet; fractures, some with 1- to 5-millimeter offset, filled with fibrous, translucent to transparent selenite, 2-millimeter displacement and 46° dip at 1,268.4 feet, 1- to 2-millimeter displacement and 54° dip at 1,269.2 feet, 4- to 5-millimeter displacement and 82° dip at 1,271.3 feet; less than 1-millimeter displacement and 56° dip at 1,272.6 feet, 4- to 5-millimeter displacement and 80° dip at 1,274.2 feet	1,267.0-1,275.2
Gypsum, dark-greenish-gray (5GY 4/1) and medium-gray (N5), wavy, 1- to 4-millimeters thick, light-olive-gray (5Y 6/1) dolomite laminae, very finely crystalline, mottled	1,275.2-1,276.3
No core	1,276.3-1,277.0
Anhydrite, olive-gray (5Y 4/1), some light-olive-gray (5Y 6/1), very finely crystalline, some zones with "chicken wire" appearance	1,277.0-1,287.0
	Bottom of cored interval

Table 6.—Lithology penetrated by borehole H-10b

Lithologic description	Depth interval (feet)
Sandstone, moderate-reddish-brown (10R 4/6), fine- to medium-grained, rounded to subrounded, very thin grayish-red (10R 4/2) laminae with horizontal to 5° dip; some small scale crossbedding at 639.2 to 639.4 and 641.6 to 641.7 feet	638.8-642.8
Sandstone, grayish-red (10R 4/2), fine- to medium-grained, rounded to subrounded, massive	642.8-643.9
Sandstone, moderate-reddish-brown (10R 4/6), fine- to medium-grained, rounded to subrounded; numerous, parallel, very thin to thin, grayish-red (10R 4/2) laminae dipping with 12 to 20° dips	643.9-645.8
Sandstone, same as in unit from 642.8 to 643.9 feet	645.8-648.3
No core	648.3-649.0
Sandstone, same as in unit from 642.8 to 643.9 feet	649.0-649.6
Siltstone, grayish-red (5R 4/2), very hard; horizontal, discontinuous to continuous, 5- to 30-millimeters thick, light-olive-gray (5Y 6/1) and greenish-gray (5Y 6/1) siltstone bands	649.6-651.1
Sandstone, light-olive-gray (5Y 4/2), very hard; horizontal, medium- to coarse-grained, rounded to subrounded; very hard, dispersed zones of greenish-gray (5GY 6/1) and brown (5YR 6/2) sandstone and irregular, horizontal, grayish-red (5R 4/2) siltstone bands	651.1-652.3
Siltstone, grayish-red (5R 4/2), very hard	652.3-653.1
Sandstone, pale-yellowish-brown (5R 6/2), medium- to coarse-grained, rounded to subrounded; horizontal, wavy, greenish-gray (5GY 6/1) laminae	653.1-653.9
Siltstone, same as in unit from 652.3 to 653.1 feet	653.9-654.2
Sandstone, same as in unit from 653.1 to 653.9 feet, few 2 to 10 millimeters in diameter, hard, greenish-gray (5GY 6/1) clay blebs becoming numerous and lenticular at 656.6 to 656.8 feet	654.2-657.9

Table 6.—Lithology penetrated by borehole H-10b - Continued

Lithologic description	Depth interval (feet)
Sandstone, pale-yellowish-brown (10YR 6/2) to very-pale-orange (10YR 8/2), coarse- to very coarse-grained, rounded to subrounded, very hard, with numerous very large irregular blebs, 2 to 50 millimeters in size, discontinuous bands of "marbeled" grayish-red (10R 4/2) and greenish-gray (5G 6/1) mudstone	657.9-659.0
No core taken	659.0-1,348.0
Anhydrite, dark-yellowish-brown (10YR 4/2), very finely crystalline, argillaceous; numerous, very thin, wavy, pale-yellowish-brown (10YR 6/2) irregular laminae dipping 6 to 10°	1,348.0-1,357.2
Dolomite, dark-yellowish-brown (10YR 4/2) and light-olive-gray (5Y 6/1); very silty, with numerous 1- to 2-millimeter gypsum blebs	1,357.2-1,357.4
No core	1,357.4-1,357.8
Dolomite, dark-yellowish-brown (10YR 4/2) to moderate-yellowish-brown (10YR 5/4), some very thin dark-yellowish-brown (10YR 4/2) laminae; few 1- to 5-millimeter sized pits; few, lense shaped, 1- to 6-millimeter gypsum blebs at 1,358.3 to 1,358.4 feet; 40 by 60 millimeters in size, rounded gypsum bleb at 1,357.9 feet	1,357.8-1,359.3
Dolomite, light-olive-gray (5Y 6/1) and pale-reddish-brown (10R 5/4), dispersed "blotchy" zones; numerous 1- to 3-millimeter sized pits at 1,359.3 to 1,362.6 feet; pitted, medium-light-gray (N6) dolomite bands at 1,361.3 to 1,361.4 feet and at 1,361.8 to 1,362.3 feet; few rounded, 20- to 60-millimeter sized gypsum blebs at 1,360.8 to 1,361.3 and 1,366.7 feet	1,359.3-1,367.6
No core	1,367.6-1,368.0
Dolomite, same as in unit from 1,359.3 to 1,367.6 feet; numerous hairline fractures; 5- to 15-millimeter sized irregular washed-out voids; 1- to 3-millimeter sized pits; some very numerous 20- to 50-millimeter sized blebs at 1,371.1 to 1,373.4 feet	1,368.0-1,377.9

Table 6.—Lithology penetrated by borehole H-10b - Concluded

Lithologic description	Depth interval (feet)
No core	1,377.9-1,378.0
Dolomite, light-olive-gray (5Y 6/1), very silty; numerous, very irregular hairline fractures; 5- to 30-millimeter sized voids and 1- to 3-millimeter sized pits; irregular bands and blebs of pale-reddish-brown (10R 5/4) dolomitic siltstone at 1,378.1 to 1,383.1 feet	1,378.0-1,386.2
Mudstone, medium-dark-gray (N4), hard, fissile	1,386.2-1,387.2
No core	1,387.2-1,387.8
Mudstone, same as in unit from 1,386.2 to 1,387.2 feet, but crumbly; very hard, medium-dark-gray (N4) and light-olive-gray (5Y 6/1) mudstone at 1,389.0 to 1,389.3 and 1,389.7 to 1,390.3 feet; very irregular, translucent to transparent selenite veins and argillaceous bands hairline to 30-millimeters thick at 1,391.2 to 1,391.3 and 1,392.0 to 1,392.5 feet	1,387.8-1,392.6
Clay, moderate-reddish-brown (10R4/6), crumbly, washed out; numerous, very irregular, translucent to transparent, moderate-reddish-brown (10R 4/6) selenite veins, hairline to 50-millimeters thick dipping 10 to 80°; finely to medium crystalline, mottled, grayish-red (10R 4/2) to moderate-reddish-brown (10R 4/6) gypsum at 1,394.9 to 1,395.3 feet	1,392.6-1,396.2
Anhydrite, light-gray (N7), light-brownish-gray (5YR 6/1), some moderate-red (5R 4/6) blotches and irregular stringers, very finely crystalline	1,396.2-1,397.5
Anhydrite, grayish-red (10R 4/2) and moderate-red (5R 4/6), gypsiferous, mottled	1,397.5-1,397.8
	Bottom of cored interval

Table 7.—Lithology penetrated by borehole H-10c

[Color designation from Rock-Color Chart (Goddard and others, 1948). Depth interval has been corrected to land surface 12.2 feet below the kelly bushing (KB) datum reported by driller and lithologic and descriptive depths have been corrected to coincide with geophysical logging depths.]

Lithologic description	Depth interval (feet)
Cellar (First sample collected from 0 to 4.8 feet then in 5-foot increments)	0-4.8
Sand, clear quartz, with moderate-reddish-brown (10R 4/6) to moderate-brown (5YR 4/4) stain and/or argillaceous material, fine- to medium-grained, rounded to subrounded, loose, unconsolidated, (slightly coarser grained at 4.8-7.6 feet); caliche, moderate-pink (5R 7/4), sandy, with orange (7.5YR 7/6) tint at 4.8 to 9.8 feet, becoming pale-orange (7.5YR 8/4) and sandier, changing to light-brown (7.5YR 6/4) caliche	4.8-14.8
No samples	14.8-107.8
Sandstone (50 percent), brownish-gray (5YR 4/1), hard, fine- to coarse-grained, poorly sorted, angular to subrounded quartz; sandstone (40 percent), moderate-reddish-brown (10R 4/6), very fine- to medium-grained, subangular to rounded quartz grains, hard, small percentage of black (N1) accessory grains; soft, incompetent, moderate-reddish-brown (10R 4/6) mudstone (10 percent)	107.8-117.8
Sandstone (50 percent), brownish-gray (5YR 4/1), same as in unit from 107.8 to 117.8 feet; mudstone (30 percent), moderate-reddish-brown (10R 4/6), same as in unit from 107.8 to 117.8 feet; sandstone (20 percent), moderate-reddish-brown (10R 4/6), same as in unit from 107.8 to 117.8 feet	117.8-127.8
Sandstone (50 percent), brownish-gray (5YR 4/1), same as in unit from 107.8 to 117.8 feet; sandstone (30 percent), moderate-reddish-brown (10R 4/6), same as in unit from 107.8 to 117.8 feet; mudstone (20 percent), moderate-reddish-brown (10R 4/6), same as in unit from 107.8 to 117.8 feet	127.8-137.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Sandstone (80 percent), brownish-gray same as unit from 107.8 to 117.8 feet; sandstone (10 percent), moderate-reddish-brown (10R 4/6), same as in unit from 107.8 to 117.8 feet; mudstone (10 percent), same as in unit from 107.8 to 117.8 feet	137.8-147.8
Sandstone (70 percent), dark-greenish-gray (5GY 4/1) to brownish-gray (5YR 4/1), very fine to fine-grained matrix, some medium-grained, angular to subrounded quartz, hard, sugary texture; mud (30 percent), moderate-reddish-brown (10R 4/6) to dark-greenish-gray (5GY 4/1), soft, pliable	147.8-157.8
Sandstone (60 percent), medium-dark-gray (N4), to grayish-brown (5YR 3/2), very fine to medium-grained, hard, subangular to rounded quartz grains; medium-dark-gray (N4), soft, mudstone (40 percent)	157.8-167.8
Sandstone (70 percent), dark-greenish-gray (5GY 4/1) to greenish-gray (5G 6/1) and medium-light-gray (N6), very fine grained, poorly sorted, calcareous, hard to friable, very argillaceous; firm, greenish-gray (5G 6/1) and medium-light gray (N6), mudstone (20 percent); firm to hard, olive-gray (5Y 4/1) and moderate-brown (5YR 4/4), argillaceous siltstone (10 percent), some dark-greenish-gray (5GY 4/1), some sandy; some "gumbo" clay, same colors as above; trace pyrite	167.8-187.8
Sandstone, greenish-gray (5G 6/1) to medium-light-gray (N6), very hard, and hard to slightly friable, subrounded quartz, some with green tints, trace of biotite flakes, trace of pyrite; some argillaceous, calcareous sandstone	187.8-197.8
Sandstone (70 percent), same as in unit from 187.8 to 197.8 feet; some olive-gray (5Y 4/1) to dark-yellowish-brown (10YR 4/2), very fine grained, friable; soft, very friable, dark-reddish-brown (10R 3/4) siltstone (20 percent); mudstone (10 percent), same as in unit from 167.8 to 187.8 feet	197.8-207.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Siltstone (70 percent), grayish-brown (7.5YR 4/2) and moderate-red (5R 4/6), hard to firm, some argillaceous, friable, and soft; firm, grayish-brown (7.5YR 4/2), some moderate-red (5R 4/6), mudstone (30 percent); some "gumbo" like clay	207.8-237.8
Siltstone (80 percent), same as in unit from 207.8 to 237.8 feet, also reddish-brown (10R 3/4), becoming grayish-brown (7.5YR 3/2); mudstone (20 percent), same as in unit from 207.8 to 237.8 feet; trace greenish-gray (5GY 4/1) mud and siltstone	237.8-257.8
Siltstone (60 percent), brownish-gray (5YR 4/1) to olive-gray (5Y 4/1), some moderate-gray (N5), firm to friable, some argillaceous, some similar to unit from 167.8 to 187.8 feet; firm mudstone to "gumbo" clay (40 percent), same colors as siltstone above	257.8-277.8
Mudstone (80 percent), same as in unit from 207.8 to 237.8 feet; greenish-gray (5GY 6/1) silt and mudstone (20 percent)	277.8-287.8
Mudstone (60 percent), greenish-gray (5GY 6/1) and brownish-gray (5YR 4/1) to moderate-brown (5YR 3/4), firm; firm, brownish-gray (5YR 4/1) to moderate-brown (5YR 3/4) siltstone (40 percent)	287.8-297.8
No samples	297.8-307.8
Sandstone (70 percent), brownish-gray (5YR 4/1), to grayish-red (5R 4/2) and greenish-gray (5GY 6/1), very fine grained, hard; siltstone (20 percent), same as unit from 287.8 to 297.8 feet; mudstone (10 percent), same as in unit from 287.8 to 297.8 feet	307.8-317.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
No samples	317.8-327.8
Sandstone (70 percent), same as in unit from 307.8 to 317.8 feet; siltstone (30 percent), same as in unit from 287.8 to 297.8 feet, some approaching dark-reddish-brown (10R 2/4)	327.8-347.8
Sandstone, grayish-brown (5YR 3/2) to grayish-red (5R 4/2) very fine grained, friable but hard, argillaceous and slightly calcareous to dolomitic matrix	347.8-377.8
No samples	377.8-407.8
Sandstone (50 percent), grayish-brown (5YR 3/2) to grayish-red (5R 4/2), very fine grained, friable but hard, slightly calcareous; firm, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 2/4) siltstone (50 percent), containing few scattered reduction spots; trace of very fine grained, greenish-gray (5G 6/1) sandstone	407.8-417.8
Sandstone (50 percent), grayish-brown (5YR 3/2), same as in unit from 407.8 to 417.8 feet; siltstone (30 percent), same as in unit from 407.8 to 417.8 feet; very soft, moderate-reddish-brown (10R 4/6) mud (20 percent)	417.8-427.8
Sandstone (50 percent), grayish brown (5YR 3/2), same as in unit from 407.8 to 417.8 feet; siltstone (50 percent), same as in unit from 407.8 to 417.8 feet; heavy trace very fine grained, greenish-gray (5GY 6/1) sandstone	427.8-467.8
Sandstone (90 percent), grayish-brown (5YR 3/2) to grayish-red (5R 4/2), medium-grained to very fine grained, subrounded to rounded, hard; siltstone (10 percent), same as in unit from 407.8 to 417.8 feet; trace greenish-gray (5GY 6/1) sandstone	467.8-527.8
Sandstone (80 percent), grayish-brown (5YR 3/2) to grayish-red (5R 4/2), most very fine grained but some medium-grained, hard; siltstone (20 percent), same as in unit from 407.8 to 417.8 feet; trace of very soft, moderate-reddish-brown (10R 4/6) mud; trace of greenish-gray (5GY 6/1) sandstone	527.8-547.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Mud (90 percent), moderate-reddish-brown (10R 4/6), very soft; moderately consolidated, dark-reddish-brown (10R 2/4), silty sandstone (10 percent); trace of hard, light-greenish-gray (5GY 8/1) sandstone; trace of dark-reddish-brown (10R 3/4) siltstone	547.8-577.8
Mud (80 percent), same as in unit from 547.8 to 577.8 feet; dark-reddish-brown (10R 3/4) siltstone (10 percent); light-greenish-gray (5GY 8/1) sandstone (10 percent); trace of dark-reddish-brown (10R 3/4), silty sandstone	577.8-587.8
Mud (50 percent), same as in unit from 547.8 to 577.8 feet; firm to friable, dark-reddish-brown (10R 3/4) siltstone (40 percent); very fine grained, light-greenish-gray (5GY 8/1) sandstone (10 percent); trace of firm, greenish-gray (5GY 6/1) siltstone	587.8-607.8
Siltstone (80 percent), dark-reddish-brown (10R 3/4), firm to friable; firm, greenish-gray (5GY 6/1) siltstone (10 percent); mud (10 percent), same as in unit from 547.8 to 577.8 feet; trace of very fine grained, light-greenish-gray (5GY 8/1) sandstone; trace of firm, dark-reddish-brown (10R 3/4) mudstone	607.8-647.8
Siltstone (70 percent), dark-reddish-brown (10R 3/4), same as in unit from 607.8 to 647.8 feet; moderately hard, very fine grained, pale-reddish-brown (10R 5/4) to moderate-red (5R 4/6) sandstone (30 percent); trace of greenish-gray (5G 6/1) siltstone, same as in unit from 607.8 to 647.8 feet; trace of firm, dark-reddish-brown (10R 3/4) mudstone	647.8-657.8
Siltstone (90 percent), dark-reddish-brown (10R 3/4), same as in unit from 607.8 to 647.8 feet; mudstone (10 percent), same as in unit from 607.8 to 647.8 feet; trace of greenish-gray (5GY 6/1) siltstone, same as in unit from 607.8 to 647.8 feet	657.8-687.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Siltstone (90 percent), dark-reddish-brown (10R 3/4), same as in unit from 607.8 to 647.8 feet; mudstone (10 percent), same as in unit from 607.8 to 647.8 feet; trace of greenish-gray (5GY 6/1) siltstone, same as in unit from 607.8 to 647.8 feet; trace of soft, chalky, white (N9) gypsum	687.8-717.8
No samples	717.8-767.8
Siltstone (60 percent), dark-reddish-brown (10R 3/4), same as in unit from 607.8 to 647.8 feet; mudstone (30 percent), same as in unit from 607.8 to 647.8 feet; siltstone grades to a very fine grained sandstone (10 percent); trace of soft, chalky, white (N9) gypsum; trace of clear selenite	767.8-817.8
Siltstone (60 percent), dark-reddish-brown (10R 3/4), firm to friable; soft, dark-reddish-brown (10R 3/4) to moderate-reddish-brown (10R 4/6) mudstone (30 percent), trace soft, greenish-gray (5GY 6/1); firm to friable, very fine grained, dark-reddish-brown (10R 3/4) sandstone (10 percent); trace fibrous clear selenite	817.8-827.8
Siltstone (60 percent), same as in unit from 817.8 to 827.8 feet; sandstone (20 percent), same as in unit from 817.8 to 827.8 feet; mudstone (20 percent), same as in unit from 817.8 to 827.8 feet; trace white (N9) chalky, soft gypsum and clear selenite	827.8-837.8
Siltstone (70 percent), same as in unit from 817.8 to 827.8 feet; mudstone (30 percent), same as in unit from 817.8 to 827.8 feet; trace gypsum and selenite	837.8-857.8
Siltstone (90 percent), dark-reddish-brown (10R 3/4), slightly darker than unit from 817.8 to 827.8 feet, hard; mudstone (10 percent), same as in unit from 817.8 to 827.8 feet; trace gypsum; trace selenite same as in unit from 817.8 to 827.8 feet	857.8-897.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Siltstone (70 percent), same as in unit from 857.8 to 897.8 feet; mudstone (20 percent), moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4), firm; sandstone (10 percent), dark-reddish-brown (10R 3/4), very fine grained, hard	897.8-907.8
Siltstone (80 percent), dark-reddish-brown (10R 3/4) and moderate-reddish-brown (10R 4/6), hard to slightly friable, some finely biotitic, trace small, sandy, greenish-gray (5GY 6/1) reduction spots; mudstone (20 percent), same as in unit from 817.8 to 827.8 feet, some sandy with rounded, clear, fine quartz grains; trace white (N9) to clear selenite	907.8-937.8
No samples	937.8-947.8
Siltstone (80 percent), same as in unit from 907.8 to 937.8 feet; mudstone (20 percent), same as in unit from 817.8 to 827.8 feet; trace white (N9) to clear selenite	947.8-967.8
No samples	967.8-977.8
Siltstone (80 percent), same as in unit from 907.8 to 937.8 feet; mudstone (20 percent), same as in unit from 817.8 to 827.8 feet; trace of white (N9) to clear selenite	977.8-1,007.8
Siltstone (70 percent), same as in unit from 907.8 to 937.8 feet; mudstone (20 percent), same as in unit from 817.8 to 827.8 feet; sandstone (10 percent), same as in unit from 897.8 to 907.8 feet; trace of white (N9) gypsum	1,007.8-1,037.8
Siltstone (80 percent), same as in unit from 907.8 to 937.8 feet; mudstone (20 percent), same as in unit from 817.8 to 827.8 feet; trace of white (N9) to clear selenite	1,037.8-1,047.8
Siltstone (70 percent), same as in unit from 907.8 to 937.8 feet; mudstone (20 percent), same as in unit from 817.8 to 827.8 feet; sandstone (10 percent), same as in unit from 897.8 to 907.8 feet; trace of white (N9) to clear selenite	1,047.8-1,077.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Siltstone, same as in unit from 907.8 to 937.8 feet; trace mudstone, same as in unit from 817.8 to 827.8 feet; trace of white (N9) to clear selenite ----------	1,077.8-1,087.8
Siltstone (70 percent), moderate-reddish-brown (10R 4/6), greenish-gray (5GY 6/1) to moderate-brown (5YR 3/4) reduction spots, random subrounded to rounded very fine quartz grains, hard, noncalcic; hard, slightly calcic, moderate-reddish-brown (10R 4/6) mudstone (30 percent), with interspersed biotite specks; trace of very finely crystalline, white (N9) gypsum and fibrous clear selenite; trace of pale-yellowish-brown (10YR 6/2) siltstone ----------	1,087.8-1,097.8
Siltstone (60 percent), moderate-reddish-brown (10R 4/6), same as in unit from 1,087.8 to 1,097.8 feet, with moderate-brown (5YR 3/4) mudstone (40 percent); trace of gypsum and selenite, same as in unit from 1,087.8 to 1,097.8 feet ----------	1,097.8-1,107.8
Siltstone (70 percent), same as in unit from 1,087.8 to 1,097.8 feet, without moderate-brown (5YR 3/4) silt, subrounded to rounded, very fine grained quartz; mudstone (30 percent), same as in unit from 1,087.8 to 1,097.8 feet; trace of gypsum and selenite, same as in unit from 1,087.8 to 1,097.8 feet ----------	1,107.8-1,117.8
Siltstone (90 percent), same as in unit from 1,087.8 to 1,097.8 feet; mudstone (10 percent), same as in unit from 1,087.8 to 1,097.8 feet; trace of gypsum and selenite, same as in unit from 1,087.8 to 1,097.8 feet ----------	1,117.8-1,127.8
Siltstone (60 percent), same as in unit from 1,087.8 to 1,097.8 feet; mudstone (40 percent), same as in unit from 1,087.8 to 1,097.8 feet; trace of gypsum and selenite, same as in unit from 1,087.8 to 1,097.8 feet ----------	1,127.8-1,137.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Siltstone (80 percent), same as in unit from 1,107.8 to 1,117.8 feet; mudstone (20 percent), same as in unit from 1,087.8 to 1,097.8 feet; trace of gypsum and selenite, same as in unit from 1,087.8 to 1,097.8 feet; some clear platey selenite	1,137.8-1,187.8
Siltstone (60 percent), same as in unit from 1,107.8 to 1,117.8 feet; mudstone (40 percent), same as in unit from 1,087.8 to 1,097.8 feet; trace of gypsum and selenite, same as in unit from 1,087.8 to 1,097.8 feet	1,187.8-1,204.0
Gypsum (70 percent), white (N9) to clear, very finely crystalline to platey; siltstone (20 percent), same as in unit from 1,107.8 to 1,117.8 feet; mudstone (10 percent), same as in unit from 1,087.8 to 1,097.8 feet; very finely crystalline, yellowish-gray (5Y 7/2) anhydrite (10 percent)	1,204.0-1,230.0
Anhydrite, light-olive-gray (5Y 5/2) to (5Y 6/1), and light-gray (N7), dense; thin, wavy, argillaceous yellowish-gray (5Y 7/2) laminae dipping 11°	1,230.0-1,230.2
Note: End of cutting descriptions, core descriptions follow.	
Gypsum, pale-brown (5YR 3/2) and pale-purple (5P 6/2) to translucent, dark-yellowish-brown (10YR 4/2), some medium-light-gray (N6), mottled, argillaceous in parts with pale-brown (YR 5/2) and yellowish-gray (5Y 7/2) material, very finely to finely crystalline; gypsum laminae and argillaceous laminae dipping 20 to 30°; laminated argillaceous light-olive-gray (5Y 6/1) dolomite band, 20-millimeters thick dipping 26° at 1,231.9 feet; several gypsum-healed fractures 3- to 5-millimeters wide, dipping 36°, from 1,233.2 to 1,234.2 feet, parallel to each other and lined with moderate-reddish-brown (10R 4/6) to grayish-red (10R 4/2) argillaceous material; gypsum becoming dark-yellowish-brown (10YR 4/2) toward bottom of unit, and dusky-yellowish-brown (10YR 2/2) in bottom 0.5 foot, coarsely crystalline selenite at 1,236.5 feet, becoming very coarsely crystalline at the contact with the underlying mud	1,230.2-1,236.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Mud, medium-bluish-gray (5B 5/1) and pale-green (10G 6/2), firm	1,236.8-1,237.4
Mud, dark-reddish-brown (10R 3/4) and moderate-brown (5YR 3/4) tint, firm, trace of greenish-gray (5G 6/1) marbeled mud throughout unit	1,237.4-1,238.5
No core	1,238.5-1,240.6
Siltstone, dark-reddish-brown (10R 3/4); moderate-brown (5YR 3/4), hard mudstone in parts; numerous greenish-gray (5G 6/1) very finely crystalline, argillaceous gypsum inclusions 5- to 30-millimeters in size	1,240.6-1,242.9
Gypsum, dark-yellowish-brown (10YR 4/2) to dark-greenish-gray (5G 4/1), translucent in parts, medium crystalline; dark-greenish-gray (G 4/1) mud seam with medium to coarse selenite crystals from 1242.9 to 1243.1 feet	1,242.9-1,244.0
Anhydrite, light-olive-gray (5Y 5/2) to dark-yellowish-brown (10YR 4/2) and medium-gray (N5), dense; some gypsiferous bands and faint, wavy, argillacous laminae	1,244.0-1,247.7
No core	1,247.7-1,250.0
Anhydrite, light-bluish-gray (5B 7/1) to light-gray (N7), very finely crystalline, hard; intermittent stringers of light-olive-gray (5Y 6/1) very finely crystalline dolomite, less than 1-millimeter to greater than 10-millimeters wide; clear fibrous selenite veins less than 3-millimeters wide in dolomite	1,250.0-1,253.5
Gypsum, medium-dark-gray (N4) to light-gray (N7), very finely to finely crystalline; bands of light-bluish-gray (5B 7/1) to light-gray (N7) anhydrite at 1253.8 to 1255.1 feet; very finely crystalline stringers to bands as wide as 0.3-foot of light-olive-gray (5Y 6/1) dolomite dispersed throughout, fibrous selenite veins less than 3-millimeters wide in dolomite	1,253.5-1,255.5

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, argillaceous; clear to white (N9) gypsum blebs at 1,255.5 to 1,258.7 feet, less than 1 millimeter wide and less than 2-millimeters long; white (N9) fibrous selenite veins, less than 2-millimeters wide, dispersed randomly through zone at 1,255.5 to 1,258.7 feet; at 1,257.1 to 1,257.2 feet dolomitic light-olive-gray (5Y 6/1) clay seam with a 5-millimeter wide white (N9) fibrous selenite vein; from 1,255.5 to 1,257.2 feet wavy, olive-black, (5Y 2/1) clay/silt laminae; from 1,258.7 to 1,260.8 feet, hard to slightly friable, increasingly argillaceous, random olive-black (5Y 2/1) laminae ----------	1,255.5-1,260.8
Dolomite, light-olive-gray (5Y 2/1) (5Y 4/1), hard, grading from silty to clayey, minor crossbedding; olive-black (5Y 2/1) bands of silty wavy laminae at 1,261.7 to 1,264.4 feet, less than 4-millimeters to greater than 20-millimeters thick ----------	1,260.8-1,270.8
Dolomite, light-olive-gray (5Y 6/1) to olive-gray (5Y 4/1), very finely crystalline; olive-gray (5Y 4/1) to olive-black (5Y 2/1) silty, wavy laminae, less than 1-millimeter wide from 1,276.3 to 1,279.3 feet, minor crossbedding; white (N9) fibrous selenite veins, less than 5-millimeters wide from 1,274.7 to 1,279.0 feet ----------	1,270.8-1,279.3
Gypsum, white (N9) to medium-dark-gray (N4), massive, very finely crystalline; speckled, argillaceous, light-olive-gray (5Y 6/1) dolomite within gypsum matrix ----------	1,279.3-1,279.9
No core ----------	1,279.9-1,281.0

Note: End of core descriptions, cutting descriptions follow.

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
No samples	1,281.0-1,297.8
Anhydrite and gypsiferous anhydrite, light-olive-gray (5Y 6/1) to translucent	1,297.8-1,307.8
Anhydrite and gypsiferous anhydrite (60 percent), same as unit above; moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) siltstone (40 percent), some with greenish-gray (5GY 6/1) reduction spots; trace of mudstone, and very fine grained sandstone	1,307.8-1,317.8
Anhydrite, light-gray (N7) and light-olive-gray (5Y 6/1), some gypsiferous, some with light-olive-gray (5Y 6/1) argillaceous material	1,317.8-1,327.8
Anhydrite, light-gray (N7)	1,327.8-1,337.8
Anhydrite (90 percent), same as in unit from 1,317.8 to 1,327.8 feet; very soft, clayey, moderate-reddish-brown (10R 4/6) mud (10 percent)	1,337.8-1,345.8
Note: End of cutting descriptions, core descriptions follow.	
Mud, dark-greenish-gray (5GY 4/1), hard	1,345.8-1,346.6
Anhydrite and gypsiferous anhydrite, light-olive-gray (5GY 5/2), dense	1,346.6-1,347.6
Gypsum, olive-gray (5Y 4/1) to dark-greenish-gray (5GY 4/1), very finely crystalline, dense, argillaceous in parts	1,347.6-1,348.9
Anhydrite, dark-yellowish-brown (10YR 2/2) and medium-light-gray (N6), some argillaceous, thin, wavy, horizontal laminae, some moderate-brown (5YR 3/4) argillaceous laminae	1,348.9-1,355.8
Dolomitic anhydrite, light-gray (N7) to light-bluish-gray (5B 7/1); light-olive-gray (5YR 3/4) very finely crystalline, dolomite, intergranular, hard, mottled; dolomite as thin laminae to intergranular; at 1,356.2 and 1,357.0 feet, clear, fibrous selenite veins, less than 4-millimeters wide within dolomitic rind	1,355.8-1,357.7

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Dolomitic gypsum, light-gray (N7) to light-olive-gray (5Y 6/1); very finely crystalline gypsum, with silty dolomite; unit grades downward from dolomitic gypsum to gypsiferous dolomite containing numerous blebs of light-gray (N7) gypsum rinds with anhydrite core	1,357.7-1,359.9
Dolomite, light-olive-gray (5Y 5/2) and (5Y 6/1) to yellow-gray (5Y 7/2), very finely crystalline, argillaceous, hard, gypsum healed fractures; blebs of light-gray (N7) gypsum, less than 1-millimeter to more than 10-millimeters wide, at 1,359.9 to 1,360.4 feet; with white (N9) anhydrite blebs having gypsum rinds, same as in unit from 1,357.7 to 1,359.9 feet; from 1,360.6 to 1,362.9 feet, pits less than 1 millimeter in diameter encompassing 80 percent of rock; at 1,362.9 feet, pits filled with very-pale-orange (10YR 8/2) clayey material; from 1,363.8 to 1,365.8 feet, very-pale-orange (10YR 8/2) to grayish-orange (10YR 7/2) clayey dolomite cut by vertical fractures, healed with light-gray (N7) platey gypsum	1,359.9-1,365.8
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, argillaceous, hard, slightly pitted and contains healed fractures; olive-gray (5Y 4/1) to olive-black (5Y 2/1) laminae, horizontal to 20° dip, less than 5-millimeters thick; white (N9) to dark-gray (N3) gypsum-filled voids and fractures; voids less than 1-millimeter to more than 10-millimeters wide and less than 5-millimeters to more than 80-millimeters long, vertical fractures, less than 1- to 5-millimeters wide, less than 0.1-foot to more than 1.5-feet long; at 1,370.7 to 1,370.9 feet unit contains angular fragments of dolomite within a gypsum matrix	1,365.8-1,378.6
Dolomite, same as in unit from 1,365.8 to 1,378.6 feet, irregular, continuous and discontinuous, 10- to 30-millimeters thick bands of pale-yellowish-brown (10YR 6/2) to moderate-yellowish-brown (10YR 6/2), softer, very argillaceous dolomite; some bands appear as filled elongated voids, several 5- to 20-millimeter sized, lense-shaped (horizontal elongation), finely to medium crystalline, translucent, and light-gray (N7) gypsum blebs scattered throughout interval	1,378.6-1,380.3

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Dolomite, light-olive-gray (5Y 6/1), very finely crystalline, very hard; few 2-millimeters thick olive-black (5Y 2/1) mud seams/laminae; translucent to medium-light-gray (N6) gypsum-filled/healed fractures, hairline to 5-millimeters thick; fractures seem to be more predominant in zones with less pits; pits 1 2 millimeters in size, both void and filled with medium-light-gray (N6) translucent gypsum, very numerous from 1,381.5 to 1,384.2 feet; few larger unfilled pits as large as 10 millimeters in size; numerous spherical 2- to 10-millimeter sized medium-light-gray (N6) translucent gypsum blebs in 1,383.6 to 1,383.8 feet ----------	1,380.3-1,384.2
Dolomite, similar to unit from 1,380.3 to 1,384.2 feet, numerous pits both void and gypsum-filled in 1,384.2 feet and 1,385.4 feet; horizontal, coarsely crystalline, translucent selenite vein 0.1 foot thick at 1,385.3 feet, dolomite grades downwards to olive-gray (5Y 4/1) argillaceous dolomite laminae; 1- to 3-millimeter size gypsum blebs becoming rarer towards bottom ----------	1,384.2-1,386.6
Mud and gypsum; mud, between olive-gray (5Y 4/1) and dark-greenish-gray (5GY 4/1) with interval from 1,386.6 to 1,387.8 feet approaching greenish-black (5GY 2/1), hard irregular low angle bands (or fractures) of greenish-black (5GY 2/1) mud; 3- to 30-millimeters thick, medium-gray (N6) to translucent gypsum veins and bands, horizontal to high-angle dips; mottled, finely crystalline, moderate-red (5R 4/6) gypsum fragments ----------	1,386.6-1,390.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Mud and gypsum; mud, moderate-reddish-brown (10R 4/6) to dark-reddish-brown (10R 3/4) at 1,390.8 to 1,391.1 feet, soft to firm; numerous gypsum veins and bands through interval as in unit from 1,386.6 to 1,390.8 feet	1,390.8-1,393.9
Gypsum, dark-yellowish-brown (10YR 4/2), light-olive-gray (5Y 6/1), trace grayish-red (10R 4/2), mottled, finely crystalline, trace of slightly argillaceous gypsum	1,393.9-1,394.5
Note: End of core descriptions, cutting descriptions follow.	
Anhydrite (80 percent), dark-yellowish-brown (10YR 4/2) and light-olive-gray (5Y 6/1), very finely crystalline, hard; hard, light-olive-gray (5Y 6/1) dolomite (20 percent); trace of clear selenite and white (N9) chalky gypsum	1,394.5-1,397.2
No samples	1,397.2-1,398.0
Gypsum (60 percent), white (N9) to light-olive-gray (5Y 6/1), very finely crystalline, moderately hard but some soft and chalky; anhydrite (20 percent), same as unit from 1,394.5 to 1,397.2 feet; dolomite (20 percent), same as in unit from 1,394.5 to 1,397.2 feet; trace of clear selenite; trace dark-reddish-brown (10R 3/4) siltstone	1,398.0-1,407.8
Gypsum, same as in unit from 1,398.0 to 1,407.8 feet; trace of clear selenite	1,407.8-1,427.8
Gypsum (80 percent), white (N9) to light-olive-gray (5Y 6/1), some medium-light-gray (N6), very finely crystalline, moderately hard but some soft and chalky; soft dark-reddish-brown (10R 3/4) mud (15 percent); siltstone (5 percent), same as in unit from 1,398.0 to 1,407.8 feet	1,427.8-1,447.8
Siltstone (80 percent), dark-reddish-brown (10R 3/4) to grayish-red (10R 4/2), soft to moderately hard, sandy; gypsum (20 percent), same as in unit from 1,427.8 to 1,447.8 feet; trace of medium-light-gray (N6) siltstone	1,447.8-1,467.8

Table 7.—Lithology penetrated by borehole H-10c - Continued

Lithologic description	Depth interval (feet)
Siltstone (60 percent), dark-greenish-gray (5GY 4/1), soft to moderately hard; mud (20 percent), dark-greenish-gray (5GY 4/1), very soft "gumbo"-like; siltstone (10 percent), same as in unit from 1,398.0 to 1,407.8 feet; gypsum (10 percent), same as in unit from 1,427.8 to 1,447.8 feet	1,467.8-1,482.8
No samples	1,482.8-1,489.0
Note: End of cutting descriptions; core descriptions follow.	
Siltstone, dark-reddish-brown (10R 3/4) to moderate-brown (5YR 3/4), hard; approaching very fine grained sandstone from 1,494.8 to 1,497.2 feet; band of greenish-gray (5GY 6/1) siltstone from 1,492.4 to 1,492.9 feet, with upper contact dipping approximately 40° and horizontal bottom contact; fracture dipping approximately 75° at 1,495.5 feet	1,489.0-1,497.2
No core	1,497.2-1,498.0
Siltstone, same as in unit from 1,489.0 to 1,497.2 feet	1,498.0-1,499.5
Gypsiferous anhydrite, olive-gray (5Y 4/1) to white (N9), mottled with moderate-reddish-orange (10R 6/6) spots; at 1,499.5 feet stringers of gypsiferous anhydrite in moderate-brown (5YR 3/4) siltstone, argillaceous in parts; at 1,500.8 a few irregular bands of greenish-gray (5G 6/1) clay, becoming halitic towards base	1,499.5-1,501.0
Halitic siltstone/mudstone, dark-reddish-brown (10R 3/4) to moderate-brown (5YR 3/4); at 1,501.3 feet horizontal stringers of greenish-gray (5G 6/1) clay	1,501.0-1,503.1
Halite, translucent, finely to medium crystalline, argillaceous, with dark-reddish-brown (10R 3/4) to moderate-reddish-brown (10R 4/6) interstitial clay	1,503.1-1,505.2
Halite, translucent, finely to medium crystalline, less argillaceous than unit above, with moderate-reddish-brown (10R 4/6) to moderate-brown (5YR 4/4) clay; scattered blebs and stringers of moderate-reddish-orange (10R 6/6) polyhalite	1,505.2-1,507.0

Table 7.—Lithology penetrated by borehole H-10c - Concluded

Lithologic description	Depth interval (feet)
No core	1,507.0-1,508.0
Halite, translucent, with grayish-red (10R 4/2) and moderate-reddish-brown (10R 4/6) tints, very finely to finely crystalline, some medium crystalline, argillaceous from dark-reddish-brown (10R 3/4) mud, very argillaceous from 1,509.5 to 1,509.8 feet, few blebs of moderate-reddish-orange (10R 6/6) polyhalite	1,508.0-1,509.8
Halite, translucent to transparent, moderate-reddish-brown (10R 4/6) and pale-reddish-brown (10R 5/4), finely to medium crystalline; numerous irregular blebs and stringers (0.2 to 2.0 cm) of moderate reddish-orange (10R 6/6) polyhalite, halite becoming transparent and moderately clean from 1,514.8 to 1,518.1 feet	1,509.8-1,518.1
	Bottom of cored interval

☆U.S. GOVERNMENT PRINTING OFFICE: 1983-679-042